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# Indices of Performance in the Racing Quarter Horse

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ABSTRACT We evaluated seventeen 2-year-old American Quarter horses on a half-mile track to identify indices that may select for performance potential prior to racing. Each horse was cantered at V140 and V180 over a measured distance. Heart rate (HR) and blood lactate were determined at rest and 3 and 5 min after V140 and V180. Stride frequency was counted to calculate stride length. The horses were ranked by these variables, and the results were compared with their subsequent performance on the racetrack. Mean V140 was 5.76 m $s^{-1}$ ± 0.60 SD, and V180 was 7.90 m $s^{-1}$ ± 0.94 SD. Resting HR was 48 b $min^{-1}$; recovery HRs were 69 and 75 b $min^{-1}$, respectively, 3 min after V140 and V180. Mean blood lactate levels were 1.0 mmol $l^{-1}$ at rest and 1.2 and 2.7 mmol $l^{-1}$ 3 min after V140 and V180, respectively. Mean stride frequency was 1.98 $s^{-1}$ ± 0.08 SD at V180. Mean stride length was 3.86 m ± 0.37 SD at V180. The results demonstrate the difficulty in assessing performance capacity, particularly under field conditions. The variables that had the best correlation with subsequent performance on the racetrack were blood lactate after V180 and stride frequency

*Key words.* Performance indices; Quarter horse; heart rate; blood lactate; stride length; stride frequency.

## INTRODUCTION

Performance capacity and fitness are very complex physiologically and difficult to assess in the equine athlete. These qualities are of interest to owners and trainers; they permit the assessment of physical conditioning, comparative estimate of performance potential, and early recognition of clinical conditions that may limit performance.[15]

The analysis of fitness, state of training, and exercise tests have been reviewed by Persson[15] and Thornton.[21] Most exercise tests[1,4,11,13,14,19,20] have been developed to estimate fitness, particularly in Standardbred trotters and pacers. These tests primarily involve the relationship between heart rate (HR), speed, lactate production, and the aerobic and anaerobic capacity for strenuous exercise.

A more precise evaluation of work performed and performance potiential can be obtained on a high-speed treadmill, where the environment and testing protocol can be carefully controlled. However, it is often more practical for the owner, trainer, or veterinarian to conduct routine evaluations and performance tests on the track. There it is difficult to consistently reproduce conditions because of the daily variation in track surface, temperature, humidity, and other weather-related factors. However, track testing more closely simulates racing conditions than treadmill testing. The objective of this study was to identify performance indices that may select for performance potential prior to racing and that could be tested on a track.

## MATERIALS AND METHODS

*Horses* We evaluated seventeen 2-year-old Quarter horses on a level half-mile dirt track at a Quarter horse training center in November and December of 1986. The ambient temperature range was 7–13°C in November and 2–8°C in December. Weather conditions resulted in the track being slower in December. The horses were on a daily train-

Table 1. *Variables measured in 17 Quarter horses during training and their relationship with lifetime points earned at the racetrack*

| Variable | Mean ± SD | Regression equation | Corr. |
|---|---|---|---|
| V180 | 7.90±0.94 | V180 = 0.0021$X$+7.8467 | 0.26 |
| LA180 | 2.67±1.13 | LA180 = 0.0063$X$+2.2162 | 0.64 |
| SF | 1.98±0.08 | SF = 0.0004$X$+1.9643 | 0.49 |
| SL | 3.86±0.37 | SL = −0.0001$X$+3.9152 | −0.04 |

V180 = the speed in m $sec^{-1}$ that results in a heart rate of 180 b $min^{-1}$; LA180 = blood lactate concentration in mmol $l^{-1}$ 3 min after exercise at V180; SF = stride frequency in $s^{-1}$ at V180; SL = stride length in metres at V180; $X$ = lifetime points; Corr. = Pearson correlation coefficient of the variable with lifetime points.

ing program on the track. They had been broken to ride over the previous 2–3 months but were not all at precisely the same level of training.

*Exercise test.* Each horse was prepared for the exercise test in a barn near the track. The rectal temperature was recorded with a Yellow Spring thermometer. Electrodes were placed on the withers and sternum to monitor HR with an EQB heart rate computer (Model HR7A). Each horse was warmed up by walking about one-fourth mile to the track, then cantered slowly over a distance of one-half mile. The same rider rode all horses. He had extensive experience in both training and racing Quarter horses, including the use of HR computers.[5] During the exercise test, each horse was cantered over 325 m, first at V140 and then at V180, measured speeds that resulted in HRs of 140 and 180 b $min^{-1}$, respectively. The rider continuously monitored HR and maintained it within 5 b $min^{-1}$ of either 140 or 180 b $min^{-1}$. HR was also determined at rest near the track and 3 and 5 min after V140 and V180. The rider remained on the horse near the track during the post-exercise period. Blood lactate was determined with a lactate analyzer (Yellow Springs Instruments) prior to exercise and 3 min after V140 and V180. Stride frequency was counted over 325 m and used to calculate stride length.

*Racing records.* The horses were ranked by the variables described and the results compared with their performance on the racetrack over the next 3 years (1987–89). Racing information was obtained from the American Quarter Horse Association records of racing activity. Racing points were awarded according to the order of finish and class or type of race; race classification is also based on the gross purse. Horses that win stakes races receive more points than in claiming races. The higher the purse, the more points awarded.

*Statistical analysis.* Data were analyzed using a regression procedure which fits least-square estimates to a linear regression model. Pearson correlation coefficients were determined to show the relationship between variables. Data from horses tested twice (November and December) were averaged for regression and correlation analysis.

## RESULTS

The results are shown in Tables 1 and 2 and Figs. 1–3. The mean V140 was 5.76 m $s^{-1}$ ±0.60 SD, and mean V180 was 7.90 m $s^{-1}$ ±0.94 SD. The correlation of V140 and V180 with lifetime points was low, −0.26 for V140 and 0.26 for V180. V140 and V180 were not measured for all horses twice because some horses evaluated in November were competing on the race track in December. The mean V180 decreased from 8.0 m $s^{-1}$ in November to 7.6 m $s^{-1}$ in December; however, this decrease was not significant.

The horses with the highest number of

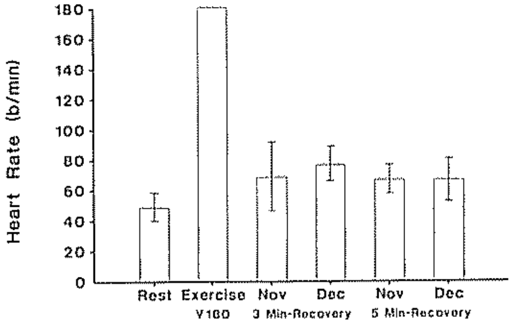


*Fig. 1* Heart rate at rest before measurement of V180, a speed that results in a heart rate of 180 b min$^{-1}$, and the heart rate at 3 and 5 min recovery. Values are means ± SD.

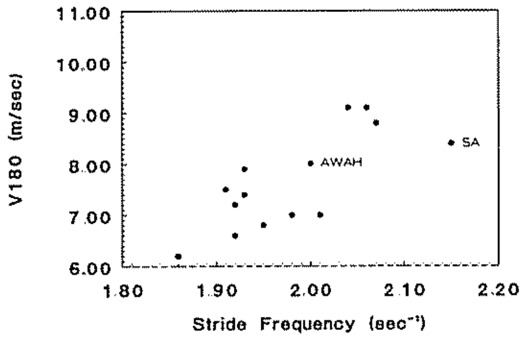


*Fig. 2* V180 plotted against stride frequency (SF) in 14 Quarter horses. The regression of V180 on stride frequency was: V180=8.8032 SF−9.6724. The correlation of V180 with stride frequency was 0.72. Horse SA had a V180 of 8.4, the highest stride frequency (2.15) and accumulated 363 points.

points generally had above average values for V140 and V180. Horse SY was awarded 300 points on the racetrack during 1987–88; this horse had the second highest V180, 9.2 m s$^{-1}$, out of 25 measurements made in November and December. Horse SA, with 369 lifetime points awarded from 1987–89, had a V180 of 8.4 m s$^{-1}$. Horse AWAH, with 219 points, had V180s of 8.7 m s$^{-1}$ in November and 8.1 m s$^{-1}$ in December.

Resting HR and recovery HRs 3 and 5 min after V180 are shown in Fig. 1. The mean resting HR was 48 b min$^{-1}$, slightly higher than the normal resting HR of 35 b min$^{-1}$ in the horse. This measurement was taken on horses that were saddled and carrying a rider, after they had completed a walk of 400 meters from the barn to the track. Recovery HRs were 69 and 75 b min$^{-1}$, respectively, 3 min after V140 and V180 and 58 and 63 b min$^{-1}$m respectively, 5 min after V140 and V180. The correlation between recovery HR and lifetime points was also low.

Table 2. *Pearson correlation coefficients showing the relationship of variables while training at V180*

| Variable 1 | Variable 2 | Correlation |
|---|---|---|
| V180 | SL | 0.93 |
| V180 | SF | 0.72 |
| LA180 | V180 | 0.71 |
| LA180 | SF | 0.77 |

V180 = the speed that results in a heart rate of 180 b min$^{-1}$; V140 = the speed that results in a heart rate of 140 b min$^{-1}$; LA180= blood lactate concentration 3 min after exercise at V180; SL = stride length at V180; SF = stride frequency at V180.

Mean values for blood lactate were 1.0 mmol l$^{-1}$ at rest and 1.2 and 2.7 mmol l$^{-1}$ after V140 and V180, respectively. The blood lactate after V180 decreased from 2.9 mmol l$^{-1}$ in November to 1.9 mmol l$^{-1}$ in December ($p$=0.025). The correlation between V180 post-exercise lactate and lifetime points was 0.64. Horses with the most lifetime points (SY and SA) had higher blood lactate values.

The mean stride frequency, determined in 1986, was 1.92 s$^{-1}$ at V140 and 1.98 s$^{-1}$ at V180. Stride frequency at V180 ranged from 1.86 to 2.15 s$^{-1}$ (Fig. 2). The correlation between stride frequency and lifetime points was 0.49. The correlation between V180 and stride frequency (Fig. 2) was higher, 0.72. The mean stride length was 2.96 m at V140 and 3.86 m at V180. Stride length for V180 ranged from 3.35 to 4.46 m (Fig. 3). The correlation between V180 and stride length was 0.93.

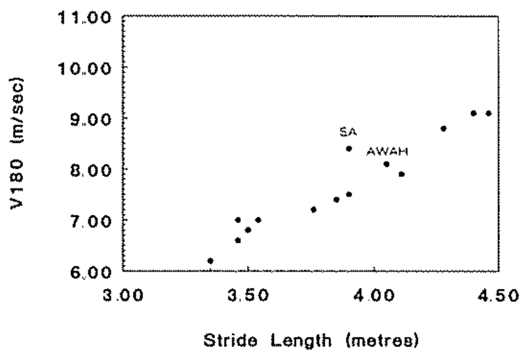


*Fig 3* V180 plotted against stride length (SL) in 14 Quarter horses. The regression of V180 on stride length was: V180=2.4321 SL−1.6318. The correlation of V180 with stride length was 0.93. Horses SA and AWAH earned 363 and 219 points, respectively. Horse SA had the 4th highest V180 (8.4 m $s^{-1}$) and the 6th highest stride length (3.9 m)

*Racing performance* Three horses had successful racing careers, documented by the American Quarter Horse Association records of racing activity. These horses received the Superior Racing Award, an award given to horses that receive over 200 points during their racing career. According to the AQHA records, only about 10% of racing Quarter Horses receive the Superior Racing Award.

Horse SY started 12 times during his 2-year racing career (1987–88), winning six races, placing second in two races and third in one race. He accumulated 300 lifetime points in 1987 and $302 111 in earlings. This horse was the fastest qualifier to the All American Futurity in August 1987, but did not compete in the finals due to an injury. SY, when evaluated in November 1986, had the 2nd highest V180 and blood lactate after V180.

Horse SA started 27 times during his racing career (1987–89), winning 11 races and placing second in two races. He accumulated 363 lifetime points and $169 340 in earnings. In December 1986, he had the 4th highest V180, the highest stride frequency at V180, and the highest blood lactate after V180.

Horse AWAH started 35 times during 1987–89, winning 11 races and placing second in six races. He accumulated 219 points and $19 737 in earnings. He had the 5th and 3rd highest V140, respectively, in November and December 1986. He had the 3rd and 5th highest V180, respectively, in November and December 1986. He had the 5th highest blood lactate after V180 in November 1986. AWAH had the 5th highest stride length and 7th highest stride frequency during V180.

## DISCUSSION

*V140 and V180.* Persson[15] has demonstrated that the heart rate/work relationship, V200, reflects endurance and fitness with respect to both cardiopulmonary and metabolic capacities. V200 is a function of the stroke volume of the heart and the arteriovenous oxygen difference, but also the rate and extent of the anaerobic energy turnover. The cardiovascular adaptations to exercise and training have also been reviewed by Evans[6] and exercise testing by Thornton.[21]

Normally, V140 and V180 increase with training; however, wet weather resulted in a slower track in December during the second evalution. This possibly resulted in the decrease in V180 from 8.0 m $s^{-1}$ in November to 7.6 m $s^{-1}$ in December; however, the decrease was not significant ($p=0.14$). This demonstrates the difficulty in standardizing environmental variables such as temperature, humidity, and track conditions when longitudinal measurements are made over time.

Excitement, apprehension, and anxiety can also affect the exercise HR.[15] The psychogenic component of HR response to exercise is proportionately larger at lower relative work loads. We observed that excitement was a more important factor during V140 than V180, and it was a little more difficult to maintain the required pace at V140.

*Heart rate.* Exercise testing on the track is often based on post-exercise heart and respiratory rates.[6] Persson[15] believed that the usefulness of post-exercise HR is often limited because of the very rapid recovery in rate immediately after the termination of work and the influence of psychological and environmental factors on the recovery of HR when approaching the basal rate. HR did recover rapidly, as noted in the 3 and 5 min recovery HRs in Fig. 1. The psychogenic factor was observed in the recovery HR in one horse which had a 5 min recovery HR of 62 b $min^{-1}$ in November and 96 b $min^{-1}$ in December. HR recovery is a better index of fitness in horses competing in or training for endurance rides.[2,8,18] HR recovery generally improves with training and can be a useful indicator of progress in fitness during training. This was not observed in the Quarter Horses evaluated in this study.

*Blood lactate.* The accumulation of blood lactate during exercise is generally an index of fitness and the degree of training.[15] It reflects the dependence on anaerobic metabolic pathways and indicates an insufficient oxygen supply to the mitochondria during exercise. The decline in lactate concentration with training results from a greater use of aerobic energy production in response to either improved oxygen uptake by and/or oxygen transport to the muscles during exercise.[20] Higher blood lactate values were observed in horses SY and SA, which had 300 and 369 lifetime points, respectively. The correlation of V180 post-exercise lactate with lifetime points, however, was only 0.64. These horses were possibly more excited, anxious to run, and their lactate concentrations may reflect adrenergic stimulation of the glycolytic pathway. Muscle biopsies were not taken so we do not know if these two horses had a larger number of fast twitch fibers than the other horses, contributing to an earlier onset of blood lactate.

*Stride frequency and stride length.* The literature contains conflicting reports on the relationship between stride length, stride frequency, and running speed. Luhtanen and Komi[12] reported a linear relationship between stride length and stride rate in the human athlete running at submaximal speeds; however, as speed increases and approaches maximum, the increase is primarily the result of an increase in stride rate. Studies on galloping horses[7,10] indicate that as speed increases, both stride rate and stride length increase. Dusek et al.[3] reported that at racing speeds, increased velocity is primarily the result of increased stride rate. Heglund et al.[9] studied species from mice to horses and observed that stride rate remains nearly constant and that increased velocity is the result of increased stride length. Studies by Rooney[17] indicated that changes in velocity are accomplished by changes in stride frequency, and stride length is adjusted to maintain the increased velocity.

Stride frequency ranged from 1.86 to 2.15 strides $s^{-1}$ in the Quarter Horses we studied at V180. The highest stride frequency was observed in horse SA, which had 369 lifetime points. Horse SA had an average stride length of 3.9 m at V180.

Ratzlaff et al.[16] reported that as horse velocity increases, stride length increases, as well as stride frequency, and stride time decreases because of decreases in both the swing and support times of the stride. Increases in stride length contribute more to increases in horse velocity than changes in either swing or support time. In the Quarter horses we evaluated, stride length increased from 2.96 m at V140 to 3.86 m at V180, a 30% increase. Stride frequency increased from 1.92 $s^{-1}$ at V140 to 1.98 $s^{-1}$ at V180, a 3% increase.

*Conclusions.* This study demonstrates the difficulty in obtaining highly reproducible data under field conditions. There may, however, be potential value in submaximal exercise testing on the track, using velocity at a known HR as an expression of work intensity. Although our results are not statistically conclusive, V180, blood lactate, stride length, and stride frequency may be useful indices to evaluate conditioning and to select for performance potential prior to racing. More work needs to be done to document the value of these indices and the indices that are the most important predictors of performance.

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